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Transportation R&D Needs
(1985)
A Review for R&D and Policy Planning

RESTRICTED CIRCULATION

Prepared By Energy, Mines and Resources
G.B. Maund

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TRANSPORTATION R&D NEEDS
(1985)

A REVIEW FOR R&D AND POLICY PLANNING

CHAPTER I - REVIEW OF ALL MODES

SCOPE

This paper reviews the state of technical development in vehicles for each transportation mode and attempts to identify the research and development needs as they apply to industry, the role that Canada can provide in these areas, and the support that could be given by government. Fuel costs represent an increasing percentage of operating costs in these modes and developments to increase fuel efficiency in vehicle use have been principally addressed. No R&D in manufacturing has been looked at, nor has fundamental research.

From these observations the particular areas in which the Panel on Energy R&D may provide support are proposed and the areas for the Conservation and Petroleum Group of the EMR Transportation Energy Division (TED) are identified. The gradual adoption of non-petroleum fuels, their R&D needs, or the growth of opportunities in their adoption is not addressed - that is a separate subject, but not reckoned to greatly affect this study.

The review is not claimed to be exhaustive nor detailed. It is essentially an endeavour to present the scope of R&D activities in the next decade or so. The exception is the chapter on automobile development which, by virtue of its 10% annual replacement and consequent opportunity for technology change, is of major interest to the Conservation and Petroleum section of TED. This mode consumes half the energy used in transportation and is a major factor in petroleum fuel use.

The approach has been to lay out the areas of R&D in each mode and to consider the developments aimed at increasing operating efficiency. This is presented in the Technology Review (Appendix 1).

The following chapters review the automobile, truck, rail, air and marine modes and the forseeable technology developments in the urban transport mode. The chapters address the following aspects:

- Background and general technology developments - global
- The R&D needs for these developments
- The R&D role in Canada
- The government component in the Canadian R&D role and the Panel of Energy R&D activity
- The R&D activities appropriate to EMR Transport Energy Division.

GOVERNMENT ROLE

The premise for the role of government is to remove the barriers or doubts in a technical R&D progression by assisting industry to the "proof of principle" stage. Where the originator is from a university, or an independent-researcher, there must be a statement of support from industry,

with the anticipated cost effectiveness of the development. Depending on the nature of the development, there may be support in a demonstration stage to effect the transfer of the technology into production.

The recommended mechanism for government support approval is a reactive one with industry and should follow the steps given in figure 1.

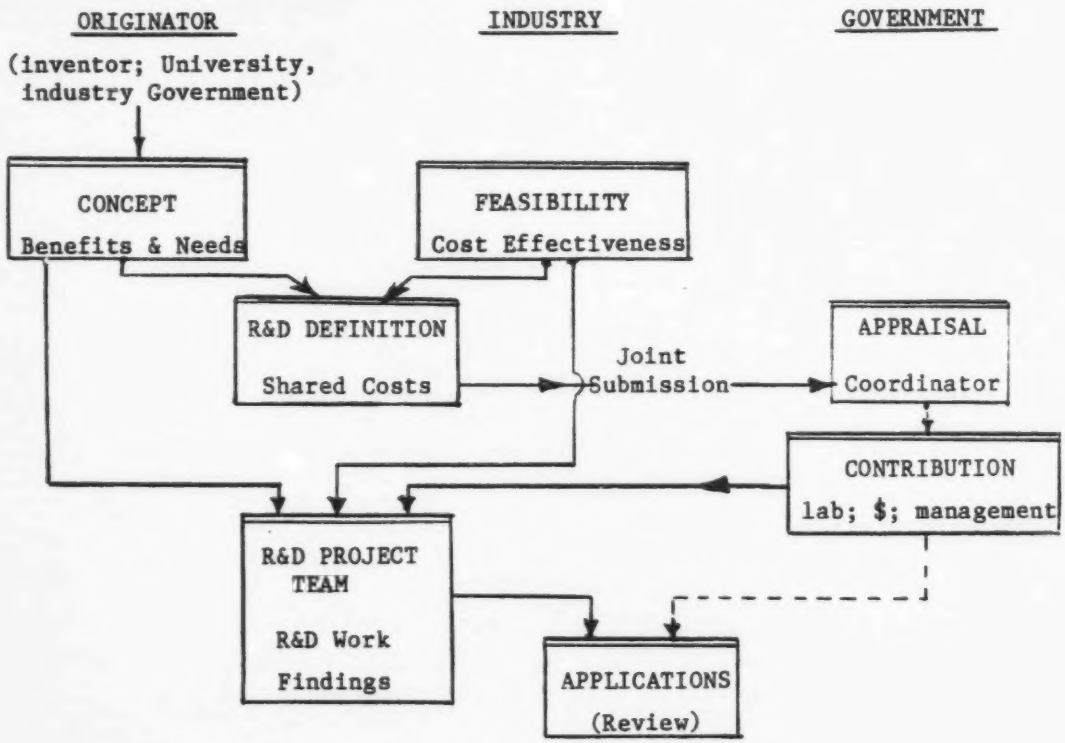

Figure 1 Proposed Industry Reactive R&D Concept & Mechanism

PROJECT APPROVAL MECHANISM

The government's contribution to R&D may be in finance, management and laboratory activity where applicable.

The above principles of government R&D acceptance ensure that support is in response to a foreseen application in industry, or to have a positive influence on the course of the industry's future in the case of long term R&D. This criterion is compatible with the needs of industrial and economic recovery and can serve government aims for energy conservation.

OBSERVATIONS

Assessment of the R&D needs of each mode has given an insight into the operation of these industries. Generally, the quickly replaced automobile needs no help. Each year a further advance in technology improves its performance and energy efficiency. These advances are stimulated by competition.

The truck and bus industry will be impacted by the imminent adoption of diesel emission control regulation. This poses questions to refiners concerning the quality of diesel fuel and to the US engine manufacturers. Emission compliance technology will require a solution appropriate to Canadian conditions before 1991.

The service life of rail stock, aircraft and ships are 20-30 years with their operators being faced with evergrowing replacement and fuel costs. New vehicles offer improved energy efficiency from better engines and optimized body strength developed by computer aided design. This is particularly note worthy in aircraft, to a lesser extent in new rail stock and not so obvious in ships. The Canadian vehicle manufacturering industry has had to assimulate these changes with little revenue to support this change and less for R&D which is centered arond a technical nucleus which is customarilly used for the application of new technologies. To ensure that the air, rail, and ship building industries are prepared to incorporate new technical advances in their product, it is proposed that government R&D funding should be made to remove barriers.

In the vehicle industries for rail, aircraft and ships, commercial returns may not be sufficient to provide the technical support required for a self reliant industry. R&D assisted by government funding can provide the technical support and create a legacy of expertise within the industries. This is strongly recommended.

PROPOSED R&D APPROACH

1) Long Term

It is proposed that Canadian requirements and expectations for its rail, marine and air modes and industries be defined up to 2010 AD. The present ad hoc fixes are not sufficient to prevent technical erosion in the vehicle manufacturing industries. Shipyards are closing, Bombardier is about to cease locomotive production, and Canadair and De Havilland are just surviving technically, if not commercially. Canada has to decide whether it needs these industries and jobs provided by this manufacturing infrastructure.

By identifying the operational needs in these modes and the role they are to play in the fabric of Canada in the new century, the operational weaknesses and shortfalls may be identified. One component will be the on-going development of technology incorporating world advances to accommodate them to Canadian conditions. This approach will have to ascribe a social and economic worth to each mode and their interrelation as foreseen in the early part of the next century. It will provide an objective for each mode and consolidate mode management in a longer term outlook. This would also serve to define the social and economic worth of each mode in an industrially integrated Canada.

The R&D strategy must evolve in the framework of a long term industrial strategy.

This proposal could be undertaken by Transport Canada, the industry interfaces of DRIE, and with strong industrial input and representation from each mode.

2) Short Term (5-7 Years)

The shorter term government funding system for R&D addresess the solutions of near term problems and development. There are many facets of funding devised from departmental responsibilities, some of which overlap and serve two or more mandates. Research laboratories of government agencies assist industry within certain terms of reference, abbreviated to form a confusing "alphabet soup" to the research proposer. A review of the overlap of mandates for funding, funding methods, limitations and avenues for an industry or researcher to obtain R&D support should be made to see if it meets present day thrusts to assist industry in job creation.

ENERGY PANEL

The Energy Panel R&D funds are serving transportation industry developments towards more fuel efficient vehicles and alternative fuels. In both cases, cost-effective solutions are serving to reduce the large percentage of operating cost that fuel represents since 1973. There is still a large benefit to be gained in both these areas as given in the following projection of fuel use, based on the technology developments foreseen up to 2000 and beyond being employed in Canada.

MODE	Fuel As A % Operating Costs(1)	Efficiency Improvement Potential 1995	Petroleum Use Reductions(2) 1990 ('000 BBL's)('000 M^3) Low Fleet Penetration Annual Fuel Saving		1995 ('000 BBL's)('000 M^3) High Fleet Penetration Annual Fuel Saving	
Automobile	33	25%	14609	2323	31303	5947
Truck	12	3%	1783	284	2037	324
		(3) (10%)	(3961)	(946)		
Rail	12	10%	786	125	1346	214
Air	28	18%	1101	175	3773	600
Marine	15	20%	500	79	1616	257
TOTAL		:-	18,779	2986	40105	7342
% Of 1983 Base Fuel Use		:-	8%		20%	
			NEAR TERM		LONG TERM	

(1) Transport Canada estimates (rounded to nearest percent) based on Statistics Canada "Financial Reports". Depreciation has been excluded from costs.

(2) Estimates of future reductions assume constant base year traffic demand--Growth in traffic would result in higher fuel consumption and potential savings.

(3) Potential without heavy duty truck emission penalty.

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Conservation of fuel used in transportation provides the benefits of lower short term operating costs and a longer term availability of fossil fuels and its gradual elimination in certain modal use. The Energy Panel R&D funding for the conservation and quality of fuel use is essential to ensure adoption of conservation technologies in Canada.

ROLE OF UNIVERSITIES

Research proposers (small companies and industry) underutilize the expertise of Canadian universities. It is proposed that some means of incorporating university input in the development of ideas and R&D activity should be found. The specialized engineering and science laboratories of Universities could contribute by being made aware of the needs of industry. They are also a fertile area for new approaches and concepts which are rarely evident in industrially proposed R&D.

It is proposed that industrial needs be passed to universities for analysis into development and research areas, each with defined sequential R&D activities and methodology for solution. Reiterative discussion and work commitments of this nature would bring university staff to focus on real problems and industry to have a developing student/researcher expertise knowledgeable of its operation and a potential source of technical employees.

CHAPTER II

THE AUTOMOBILE

2.1 TECHNICAL SURVEY

Initially the automobile, and later light trucks will undergo significant changes in the next decade. Engines are being developed which are generally smaller in capacity and fuel use particularly in Europe and Asia which, as an automobile supply area now includes Korea as well as Japan and later Taiwan. Two distinct markets are foreseen, the first, a mass produced small and fuel efficient automobile for the developing areas of S.E. Asia and China who will also supply the developing states of Africa. The second will be the sophisticated luxury equipped and highly competitive and stylized automobile as of Europe and the Americas.

In the latter market there will be features which provide additional power on demand, as a two tier-power system to provide the brillant performance of the automobile of 10 years ago which were generally overpowered. For the first time attention is being given to effectively matching engine power to road performance.

2.1.1 Vehicle Changes

The innovations which are changing the automobile have been known in principle for a long time, but have now been applied in production engineering at competitive costs, often using new materials. They are outlined in a time scale perspective in the Page 1 of the Technology Review (Appendix 1).

Advances in transmissions will further enhance the improved fuel conservation of engines with the advent of continuously variable transmissions (CVT) which ultimately will be electronically matched to the engine power/speed capability.

Structural changes have already been made and most car bodies are constructed to optimise the use of material and provide an integral strength for rigidity, durability and impact resistance in crash conditions by the use of computer aided designs employing finite element stress analysis. New moulded composite laminates of resin and metal are being researched, having the potential of incorporating strength members, fastenings, fittings and finish to resist corrosion and road abrasion with their strength and weight superior to steel pressings. New glass compositions provide thermal characteristics which reject solar radiation and internal radiant heat dissipation, permitting cooler cars in summer and warmer in winter - a necessary adjunct for motoring comfort without bleeding the heat available from smaller powered and highly efficient engines. The pace of introducing these new material will be dictated by market activity.

Engines are foreseen to be predominantly 4 cylinder, 4 valve or supercharged, resulting from US and Japanse competition. Also foreseen is the merge of technologies from this competion. In fact it may drive US and Japanse hardware together for two reasons. First, it is more profitable not to compete but to use one another's hardware. Secondly, the importation of unit "Hi Tech" components made to specification in the developing countries of Asia with their lower labour cost content also increased profits.

Low cost automobiles and trucks from Korea, Taiwan and later China based on expired designs from Europe or Japan are foreseen to fulfill a mass market in developing countries, with a luxury model made principally for the western world. The Hyundai "Pony" and "Stellar" are fore-runners of this class.

While these cars use outdated engine transmission technology they are expected to make a world impact. In Europe and North America the purchaser will be one who has never owned a new car before, yet is given the opportunity of purchasing luxury, comfort and prestige features in a serviceable vehicle.

2.1.2 World Production

World wide over-production of automobiles could occur from the developing Asian countries, supplemented with Japanese production and the establishment of Japanese and European production lines in the USA. Any interruption to the steady price of gasoline and its availability would alter this scenario, as would import restrictions (as seen in Canada and USA) or fuel tax burden (e.g. Denmark).

The writer foresees automobile types being in two strata,- the sophisticated stylish and fuel efficient of the developed world and the practical and reliable "Folk's Wagon" of the developing and 3rd world countries fulfilling the VW "Beetle" role of the western world in the 1930s, 40s and 50s.

The significance to Canada of increasing world production is a highly competitive buyers market existing in the next few years.

2.2 R&D NEEDS (GENERAL)

The development of technologies previously mentioned results from commercial competition and governmental R&D backing. In Europe government support varies from country to country but is found in selective projects in all countries. In Japan government support is mainly via university projects which are proposed and cultivated by industry to reflect their needs and train engineers and designers.

The R&D requirements of emission control for gasoline powered automobiles has been pioneered in the USA and Europe. The U.S. standards will apply in Canada (1987) and in the European common market where they are in the form of an incentive rebate to road tax. These standards may later become a common legislative requirement of all European countries. Japan has had emission regulations for many years, but supplies a product to meet "all world conditions" of fuel economy and emission regulations.

R&D for the solution of particulate control of diesel emissions is a new field which involves interactive fuel economy and emission technologies. This will initially affect trucks and cars in 1988 with more stringent limits in 1991 to 1994. The added cost of the control systems may detract users from choosing diesel engines, particularly buses where low 1991 particulate limit may provoke moves to alcohol fuel in 2 stroke diesel bus engines.

2.3 R&D NEEDS IN CANADA

The technical developments and applications foreseen during the next fifteen years in automobiles and light-trucks is shown in page 1 of the Technology Review. The supporting research for these advances is almost entirely borne by industries based outside Canada. The exception is the limited R&D undertaken by Canadian accessory companies. The need for special particulate controls on diesel powered trucks is an opportunity for Canadian industry and may be developed for light duty trucks where diesel engine use is likely to grow in future years.

Canada has no original automobile design manufacturer. For this reason Canadian automobile R&D efforts should be directed to component supply industry. Government R&D focussed on development to the "proof of principle" stage for registering Canadian master patents and designs leads to a more self reliant industry. Local universities could and should be engaged in research or development aspects proposed by industry to generate technical expertise, ideally funded from an industry/government source.

Specifically, Canadian Fram Ltd. has developments for reducing engine accessory loading and limited cold weather fuel economy improvement. The "Kerrtrain" transmission should be applied as a development project for reduced energy use in all road vehicles. Appendix 1 details the areas of vehicle advances foreseen to 2000 A.D. - most of which have little Canadian R&D opportunity and endeavour.

2.4 R&D ROLE - FEDERAL GOVERNMENT/PANEL ON ENERGY R&D

The technical development of fuel efficient cars and light duty trucks is now stimulated by competition. In fact, the desire to achieve a good fleet fuel economy may occur from competition with the lower cost Asian imports.

By 1990 this may not be the case due to price competition from automobile imports. Therefore EMR has the need to monitor the continuing improvement of fuel consumption in the automobile area. It should also monitor and actively engage in issues resulting from fuel changes which are foreseen to occur - largely from changes of additions (lead, MMT, Oxygenates).

The monitoring and research steps and operations necessary for EMR to keep abreast of the quantity and quality of light duty fuel is given in page 2 of the Technology Review. These items will be addressed by industry discussions with the Government and Industry Motor Vehicle Energy Committee (GIMVEC), the CGSB and liaison with the International Energy Agency.

This activity also forms the basis for publicity or other "Outreach" activities for maintaining public awareness of fuel conservation. Some of this work is engineering update and analysis with a continual interface with industry, other work relates to the behavioral use of older leaded gasoline fuelled vehicles and newer unleaded fuel use, for quantity and type projection activities.

This "Soft" R&D is necessary for policy formation on issues of future oil use, reduced lead, emission sensitivity, MMT concerns etc. This is all "A" base type activities. There is good reason to use Provincial Government Offices and the Canadian Automobile Association as a link in the Public Information Route.

Fuel composition changes (e.g. refinery crude quality change - or plant change) which will require an R&D assessment project to provide advance information on the effect of changes. These are generally longer term and can be planned in the annual Energy Panel R&D disucssions.

2.5 R&D ROLES AND ACTIVITIES - EMR - TRANSPORT ENERGY DIVISION (BRANCH 1987)

An interactive role between EMR and the automobile industry is set in the Government Industry Motor Vehicle Energy Committee (GIMVEC). There are on-going review functions of fuel quantity and quality used, and from these areas of concern over low temperature effects, diesel fuel quality, emission regulation impact on heavy-duty diesel vehicles. There should be provision for hard evaluation R&D in the following areas:

- Canadian developed fuel efficient technology
- Fuel consumption and/or emission evaluation due to fuel change
- Canadian climate effects on fuel consumption/emission control technologies.

Soft R&D in Technology Review, Vehicle Application and Use will be an ongoing activity and will provide input to GIMVEC discussions. A typical example is in the improved fuel economy being only now introduced in lighter trucks. This group represents 17% of the road fleet and is clearly a candidate for change. Some evidence points to increasing diesel fuel use with consequent emission concern.

The R&D requirements are short term investigational projects, better accommodated in an "A" base funding allocation. Only occasional Energy R&D panel funding is foreseen and may be planned for in advance.

CHAPTER III

THE URBAN TRANSPORTATION SYSTEM

3.1 THE URBAN MODE - GENERAL SURVEY

The movement of people and goods in urban areas has received a great deal of attention over recent years due to the growing population in cities. In Japan the dense population has resulted in particular attention to rapid train transport to suburban areas and specialized bus services, but the succes of this "journey to work" service solution has now been compromised by the increased use of private automobiles.

In North America the autombile has been the prime form of transport for so long that special endeavours have to be made to usurp the habit of automobile use and independence by providing an attractive commuting system.

Incentives based on principles of saving fuel and reducing pollution by ride sharing in private transport have been partially effective thrusts to change the use of the private car in urban transport.

No comment will be made on the effectiveness of these approaches, suffice to say that the Japanese "solution" of some 20 years ago is being drowned in the proliferation of private cars, which has become a common problem in the western world. Europe grew into the problem, largely aggravated from its past legacy of narrow roads and high population density and is constrained in its solution. The Americas have entered the 20th century with road transport as the predominant mode, with cars becoming increasingly available.

The "Urban" section of the Technology Review lists the hard and soft aspects of development and R&D activity.

Soft R&D in study form is voluminous. With the premise that the car is here to stay, the problem can perhaps be divided into how to reduce their density in cities and how to accommodate the need for urban travel in an orderly comfortable and quick manner - particularly the journey to and from work. Each city has its own problems, and most large municipalities have studies and proposed solutions which are costly to effect and are politically involved.

Urban goods movement is a special feature in each city and a consequence of siting goods warehouse and the distribution centres. The congestion quotient from this traffic source and its solution is seen to be largely with city planning and municipal traffic departments for siting stock and distribution points, traffic routing and the timing of these movements.

The Hard R&D concerns the vehicles that can be used for people moving. These vehicles are largely developed in their form, but have the prospect of using advanced engines and transmissions, some of which could be Canadian specific. These vehicles include

- Bus, single /double deck or articulated, powered by diesel, electricity, or alternative fuel, ideally using dedicated transit throughways in the city road system
- Trolley car - electric powered - has a dedicated road track
- People Movers, - light slow moving trains of up to 4 carriages on a guided rail or monorail, sometimes suspended from a 10 metre elevated support system - circular route, double route or shuttle route arrangements, wholly computer driven and controlled over a few miles.
- Intermediate capacity transit train systems, - high (50-80/km/h) speed light structure peak load train services for work and return travel peaks - usually up to 20 miles service across a city and operating on existing tracks (sometimes dedicated track systems)
- Metro rail systems - used in densely populated/travelled city area and largely underground; are now almost prohibitive to construct due to civil engineering cost escalations.

3.2 R&D NEEDS (Reference Technology Review Appendix)

Soft R&D into the problems of city traffic loading is periodically made in large cities and the search for a solution is on-going. It appears that particular attention is to be paid to the following areas:

- Controlling road traffic in cities (including banning traffic in certain areas)
- Providing dedicated bus lanes in city arterial routes
- Expanding these lanes to a network of bus routes with good interchange facilities
- Eventually moving to an intermediate capacity train system on these dedicated road lanes
- Planning new cities or urban renewal with the provision for advanced overhead people mover or rail system.

Hard R&D on the particular propulsion and form of the transport vehicle is on-going and covers:

- More efficient bus engines, with improved efficiency in transmission - leading to regenerative braking.

- Less polluting bus engines
- Electric train propulsion by linear motors coupled with magnetic levitation (eliminates tractive friction - but still has guidance friction)
- Electric trolley and battery bus
- Electronic vehicle control and guidance on people mover system
- Electronic information systems to all passengers or prospective users (at home) of any system on the actual service conditions (important on road systems - less on rail systems)

3.3 R&D ROLE - CANADA

The Soft R&D studies of traffic flow and urban road design had some centre of focus in the former Department of Urban Affairs, which also had recourse to methodology and demonstration research by the T.C. Transport Development Centre. There is a perceived need for some centre for this work and for developments in city planning, transit system design and traffic control. The centre would provide resource to specific studies, and act as a guidance or reference centre for city planners. It could be University based.

Page 5 of Appendix 1 gives the areas of municiple management and activities. They fall into:

- demand management - measures
- supply management - road system
- supply management - transit systems
- urban form - advanced urban planning

The Hard R&D areas will primarily benefit Canadian Vehicle Manufacturers. Bus manufacturers in Canada use U.S. diesel engines and transmissions, although the construction of the vehicle is individually developed.

Apart from energy aspects related to the engine and transmission, there are impending exhaust emission limitations which have specifically Canadian aspects due to the type of diesel fuel and cold start emission characteristics.

There are two particular energy use aspects. The stop and start mode of bus operation makes it the most attractive application for continuously variable transmission (CVT). A version of this CVT system is being developed in Canada. The other is the storage of braking energy, for reuse in the following acceleration. This regenerative braking aspect could be developed in Canada (NRC have a hydraulic design) and the above mentioned CVT system (Kerrtrain) could be associated with a flywheel storage system.

The emission concern is the possible adoption of the U.S. Heavy Duty vehicle diesel emission regulations in Canada. This would impose an extraordinary severe particulate emission limitation in 1994 which may not be met when using Canadian diesel fuel (due to the characteristics of Canadian creosote slates.) This may drive the adoption of gasoline powered buses, or alternative fuelled engines, or electric trolley bus units.

The fuel quality impact on emission systems and any adverse fuel economy impact needs to be quantified by testing with follow up R&D addressing specific solutions to these impacts.

3.4 R&D ROLE FEDERAL- GOVERNMENT/PANEL ON ENERGY R&D

Hard R&D

Support for regenerative braking technology development is long-term and high risk. It is considered a candidate for Energy Panel funding, initially to validate the performance of a bus system cut designed by Kerrtrain and finally to design a hybrid power control system for charging and discharging flywheel energy.

The fuel economy penalty and particulate emission control resulting from adoption of U.S. diesel emission standards on buses (1994) is a matter which needs immediate review. This aspect is dealt with in the following section on Trucks and should be persued there as these regulations have an earlier impact on trucks (1987 & 1991).

The role of the government in adopting U.S. Heavy Duty Diesel Emission Regulations is recommended to be one which directly assesses the fuel economy penalty of such regulations when they are applied in Canadian conditions. These conditions are different to the U.S. in that:

- The diesel fuel is more aromatic which gives rise to increased particulate emissions.
- The technology of reducing emissions include de-tuning the engine and trapping the particulates - both may impair fuel economy.
- The particulate traps are purged by catalytic burn-off. The trap design is sensitive to engine and fuel quality in the aspects of i) unburnt hydrocarbon emission at cold start ii) sulphur content of fuel iii) aromatic content of fuel.

The designs of Canadian particulate emission trap manufacturers should be an R&D aspect to be addressed during the next 3 years, to be followed by field experience on truck and bus diesel engines. Such an assessment is considered to be within the Energy Panel funding.

Soft R&D

Para transit systems such as shared-ride from vanpools or car pools can be effective contributions to urban energy saving. Computer matching for applicants and routes is now developed and the system is part of a publicity outreach program.

Outreach programs to follow upon the success of energy saving achievements and to maintain or extend their use, are seen to be left unfunded. There is a need for continuing the success by finding funding support for their mission.

Areas of municipal transit management are listed for completeness and the fact that there is no assistance given from federal government departments to develop more effective management systems. The returns may rate low on the scale of energy return for dollar spent. Municipal involvement is also a delicate and sometimes unstable area to attempt changes. A central focus for studies in the areas is recommended

3.5 ACTIVITIES - EMR ROLE - TRANSPORT ENERGY DIVISION (BRANCH 1987)

3.5.1 Buses

Development of emission control equipment - Support the moves of any Canadian component manufacturer

Methodology

Evaluate the cost penalty of operation incurred by adoption of the U.S. emission regulations resulting from;

a) increased fuel penalty from engine/trap units and cost of trap units

b) change of diesel fuel to accommodate the regulations

c) change of diesel fuel demand by a switch to alternate gasoline or non-petroleum fuel.

Support for more efficient bus engine and transmission systems. TED would not assume a lead role, T.C. probably would.

3.5.2 Urban Transit Systems

Ascertain key areas of change for fuel and pollution reduction within transit systems. Analyse the alternative sub modes (cars, buses, etc.) of Transport in typical systems for a common feature which could result in an energy efficiency contribution. Arrive at a case for demonstration with cooperation of municipal government.

Traffic regulation by synchronized energy based signalling and improved transit despatch systems can offer better service and energy reduction.

Replacement of urban stop signs by "yield" signs is another area.

CHAPTER IV

TRUCKING

4.1 TECHNICAL SURVEY (GLOBAL)

Of the total freight transported within continents, more than half is moved by trucks. Transcontinental trucks have gross vehicle weights of up to 70 tonnes, intercity have up to 25 tonnes and small trucks are essentially within-city delivery, being less than 7 tonnes. A general summary of on-going R&D in areas of engine, transmission, vehicle form and aerodynamic drag will be described separately in the following sections. A comprehensive report "Recent Reference in Heavy Duty Truck R&D" is given in reference xx. A summary of Truck Development is given on Pages 6 and 7 of the Technology Review.

4.1.1 Power Units

Heavy Duty Engines are predominately diesel due to the 35-37% thermodynamic efficiency of the diesel engine and the lower cost of diesel fuel. Inter-city and urban distribution trucks are often powered by gasoline engines (25-30% thermodynamic efficiency) depending on local conditions of engine and fuel cost after taxation. The heavy duty diesel engine is more costly and durable, and present engine designs are aiming toward one million miles service before major overhaul. This compares with the 100,000 mile limit for a gasoline truck engine.

Europe and Asia use mostly diesel powered vehicles in transcontinental freight, and for intercity and urban use, including transit bus services. Some urban distribution vehicles use gasoline engines.

In North America diesel power is used for transcontinental and some intercity freight work. The balance and urban delivery is mainly gasoline powered, but transit bus services use diesel engines. Dieselization of the intercity and urban distribution in North America is growing as more attention is paid to operating efficiency. But this tend may be retarded by stingent diesel emission regulations in the USA which come into force in 1987 and are firtjer tightined in 1991 and 1994.

In the field of engine design, USA manufactures have recently marketed a new series of engines for heavy duty trucks, which provide high torque at low engine speeds for increased fuel efficiency. The thrust for more efficiency will continue with several approaches. There is a potential for twice the power per cylinder in ten years time, accompanied by a potential increase in the thermodynamic efficiency from 37% to 42%. The greatest advances in improved design are taking place in Europe and Japan where the research is exploring the combustion process at almost a molecular level. Advanced electronic control and the refining of

existing technologies with new materials and processing are also being researched. These manufacturers are about to enter the North American diesel truck engine markets with more efficient engine designs. Tabulated areas for engine R&D are shown in the Technology Review pages Appendix 6 and 7.

The general lowering of fuel quality foreseen over the next few decades is a problem being faced by engine designers, coupled with exhaust emission controls which have been legislated in the USA. In fact, much of the foreseen fuel efficient technologies may be sacrificed in North America to meet the emission regulated of the U.S.A.

4.1.2 Transmission

Almost universally the transmission is a manual changed gear system of up to 16 selections. The gear ratios are chosen by the manufacturer to match the power for a particular road performance to the engine speed/torque characteristics. More efficient matching is being developed to provide the driver with a reduced range of gear change yet effecting a more optimized and automatic selection of gears by electronic control. This results in the development of semi computer controlled change operations and will ultimately result in automatic transmissions of extreme efficiency. The ultimate in these transmission designs involves a stepless ratio system of positive drive, or "continuously variable transmission" (CVT). The next stage will incorporate storage of braking energy in an on-board flywheel or hydraulic accumulator system, for application on the following acceleration.

For trucks, the application of CVT systems is thought to be circa 1995; more advanced systems may be commercial at the turn of the century, but both are likely to be seen in urban buses in 1995.

4.1.3 Configuration and Equipment

The configuration of trucks depend on their function. Various configurations are offered accordingly in urban and intercity duties. The long haul class 7 & 8 trucks are combinations of tractors and trailers responding to provincial road limitations of width, height and axle loadings. All should use radial tires in view of their lower (20-30%) rolling resistance and the vehicles should be as stream-lined as possible.

In windless flat conditions the resistance to motion of a single truck or trailer is shared equally at 80 km/h between the rolling resistance and aerodynamic drag. Tire rolling resistance is unlikely to be much reduced by wall, belt and tread design. One third of rolling resistance of class 7 & 8 trucks and trailers is in the wheel bearings. This is an area for study.

Aerodynamic drag is the predominant resistance above 80 km/h apart from gradient climbing. Attention is being given to the tractor profile, but aerodynamic losses between tractor and trailer, trailer side and under body turbulence are still to be addressed as well as acceptable faring methods. A rounded top edge of trailer wall - and roof is not accepted by users. Competitive designs from Europe and Japan may alter this attitude in time. In the meantime there is much information about the choice and operation of a truck that is not fully communicated to purchasers and operators and which could be provided by an "Outreach" program.

4.2 TRUCKING - R&D NEEDS (GENERAL)

4.2.1 Engine

More efficient engines are now being researched and developed for use on diesel fuel in the following areas.

1) Combustion technology using laser interferometry and spectrographic techniques for:

   - air swirl annemometry of air passage at cylinder entry and charge mix after piston bowl impingement
   - fuel spray pattern distribution in swirl at compression conditions
   - fuel spray location for wall/piston/intermediate impingement
   - combustion inception and form of physical burning
   - combustion process, fuel pyrolysis, autoignition, flame spread and burning rate, temperatures, direction of burn, process of combustion, quantity and identification of exhaust products and soot formation.

2) High Pressure Injection, direct into cylinder at a chosen rate of dispensation, optimized by electronic control and nozzle design

3) Engine Sensors to more efficiently control engine function for use with a microprocessor management system.

4) Engine Control Integration optimizing engine sensor information for fuel use/emission/power management at all engine speed/torque regimes.

4.2.1 Engine R&D Needs

I) R&D of a combustion nature to identify a more adequate parameter than ignition delay (Cetane Number) on a standard reference engine, particularly for high (60-70%) aromatic content fuels.

II) The correlation of that parameter to an index that can be calculated from easily measured properties of the fuel. (An equivalent to the Cetane Index), or

III) R&D on increasingly aromatic fuel of lower "cetane" level, an increasing problem in Canada.

IV) Combustion R&D to more effectively burn fuel (in a controlled heat-release) to improve the thermo-dynamic efficiency of the engine.

V) Combustion chamber and injector design to accomplish:

- efficient burning
- "controlled" gaseous formation
- reduction of particulate emission
- improved cold-start performance at low temperature

VI) Design of minimum pressure drop, flow-through particulate trap with continuous or intermittent self-purging features.

VII) Assisted combustion techniques of any form which facilitate operation on low cetane fuel e.g.,

- IDI chamber entrapment of exhaust gas
- controlled glow/spark plug
- plasma discharge
- laser ignition
- pilot fuel injection
- two stage injection

4.2.2 Transmission Needs

Specialist transmission companies in Europe USA and Japan are developing several types of a "pre-selector" gear system for trucks which will automatically engage an appropriate gear combination according to the road load and engine torque/speed conditions. These systems will evolve gradually from applications in light-delivery trucks, through medium, and finally heavy duty trucks.

In parallel there is the development of continuously variable transmissions now about to be marketed in automobiles. These depend on newly developed friction drives through belts or clutches. They are at the moment ready for service trials on cars - but are not mature technology for truck or bus use. Only a few have a reversible drive efficiency for transmitting power from the road wheels (e.g. down-hill over-ride) to the engine which is necessary for regenerative power storage in a flywheel or hydraulic system. This regenerative feature is an attractive energy saving proposition for urban delivery trucks and city buses.

An unusual application of pre-selector and CVT drives may emerge from the stringent diesel particulate emission standards of the USA issued in March of 1985. These regulations call for a very stringent standard of particulate emission in 1995 (0.1gm//BHP.h) the attainment of which may be assisted by computer controlled gear selection to avoid those engine conditions which generate excessive particulates.

There is a need to examine this approach which could yield both fuel economy (improved power-matching) and an emission control feature.

4.3 R&D ROLE CANADA

There are no diesel engines manufactured in Canada. There is concern that present and future Canadian diesel fuel qualities may require special exhaust emission controls to meet new North American particulate regulations.

Diesel emission trap systems are being designed in Canada for U.S. truck builders and should be assessed to ensure that their design covers the use of lower quality Canadian diesel fuel.

The automotive component industry in Canada has diverse specialities serving an industry largely sited in the USA. Items for development are the daily concern of DRIE. In Canada, the two fuel efficiency items identified are the 63 step CVT of a reversible type employing conventional gear systems engaged by over-riding clutches. This has reached "proof of principle" stage in a 200 BHP design. This is a candidate CVT for fuel economy, regenerative energy storage, and special power management. It is being developed by "Kerrtrain". A further item of fuel economy is the development of a two speed drive for engine accessories, which reduces the continuous accessory power load (10-20 HP in trucks). It is being developed by Canadian Fram Ltd.

Trucks are built in Canada. The development and market prospects for low aerodrag configurations should be sought, with respect to developments already underway in the USA.

4.4 R&D ROLE - FEDERAL GOVERNMENT

Canadian product modification and production R&D are appropriate to the mandate of DRIE, which would also logically assume any assistance to industry for implementing the production of hardware resulting from the following fuel/engine efficiency areas of R&D.

Three areas of Research, Development and Demonstration have been identified:

1) DIESEL PARTICULATE EMISSION CONTROL (Clean Air Benefit - Possible Fuel Use/Cost Penalty)

The concern about Canadian diesel fuel producing greater particulate emissions from truck diesel engines than US fuel/engine systems must be addressed.

2) ENGINE - TRANSMISSION POWER OPTIMIZATION. (Benefit 5-20%, Dependant on Service Conditions)

Any Canadian initiatives in the automotive components industry should be fostered with strong industrial financial participation.

Reduced engine accessory load is a feature under development by Canadian Fram Ltd. It is near term and may require assistance.

Computer controlled CVT development by Kerrtrain and Linomar are of a long term nature. The design is extremely promising. The need is for a fully engineered design to be tested.

3) VEHICLE CONFIGURATION (10-15% Fuel Use Benefit on Class 7 and 8 Trucks)

Aerodynamic opportunities may gradually be accommodated with style changes now taking place in long distance trucks. The technical opportunities should be reviewed between the Canadian truck manufacture and the National Research Council to establish the need for applied R&D in this field.

4.5 R&D ROLE AND ACTIVITIES - EMR AND TRANSPORT ENERGY DIVISION

Only fuel/engine/vehicle interactive systems which affect the fuel use and quality are considered in the following project proposals as part of the National Conservation and Alternate Energy Initiatives and are considered candidate projects for the Panel of Energy R&D. Project titles are given below with the project activity given in Appendix 2.

Title — Diesel Particulate Emission Control (EMR-TED)

Benefit — Clean Air - Possible Fuel Use Penalty Avoidance

Object — To ascertain what increase/decrease of particulate emissions occur with present quality Canadian diesel fuel and projected higher aromatic and lower cetane fuels up to 2000 AD, over emission control designs based on US quality fuel. To ascertain any fuel economy penalty and (alternatively) fuel quality problems by refinery improvement of fuel processing. Costs of emission hardware solution of the alternative refinery processing costs.

Title Evaluation of Canadian Developed Particulate Traps

Benefits
Assist Canadian trap designers to cope with Canadian Emissions, particularly the 295,000 mile durability requirement of Class 7 and 8 trucks when operating on future higher aromatic diesel of low cetane.

Object
Ascertain the appropriate trap design and burn-off cycle with respect to test fuels.

Title Reduced engine accessory loading by planned off/reduced loading (TED)

Benefit
10% fuel economy potential from 2 speed accessory drive

Object
To provide documented fuel economy testing

Title Engine - Transmission Power Optimization

Object
To assess 300 BHP bus transmission design in contributing to fuel economy and emission reduction (TED-TC)

Outputs
Certified test evaluations should place developer in position for commercialization

Title Aerodynamic drag reduction of truck tractor and trailer (TED-NRC)

Benefit
10 - 15% fuel economy potential from various trial faring and turbulence reducing methods

Object
To carry out tests with industrial partner proving fuel economy benefit

Title Truck outreach program

Benefit
To extend all technical and operational assistance to truckers based on the above R&D and other international R&D to benefit the Canadian trucker

Object
Positive information and application program

I Need to assess the increase of particulate formation arrising from the increasingly aromatic content of Canadian diesel fuel

II Methods of control by particulate trap systems up to 2000 AD

III R&D in Canadian trap development and marketing

IV Assess the reduction of fuel efficiency resulting from the adoption of severe particulate and NO_x emission controls and the projected fuel increase

V Assess the price burden to the trucking mode

a) with new engine and exhaust systems

b) alternative to (a) - the refinery cost to reduce the aromatic content and raise cetane level of Canadian diesel fuel

c) consequent on (a) and (b) the burden on the trucking industry

d) the competitiveness of the trucking industry with either burden to the rail mode.

PROJECT 2 (Wholly EMR - TED)

Outputs Canadian enterprise assistance for solving a 1995-2000 AD problem unique to Canada.

Work Activities

1) Establish EPA transient cycle test facilities with precision exhaust gas sampling system

2) Calibration of test equipment

3) Comparative trials of exhaust traps on a typical Class 7-8 truck diesel engine

PROJECT 3 (Lead by T.C. Supported by EMR)

Work Activities:

I) Establish functional bus control and fuel economy

II) Trials to assess implementation in particulate emission reduction

III) Trials to assess transient transmission shock performance

IV) Durability and failure mode(s) determination

V) Prototype bus design for trials.

PROJECT 4 (Wholly EMR - TED)

Output Certified evaluation should open commercialization

Work Activities:

Arrange tests with Canadian Fram Ltd.,

PROJECT 5 (TC - EMR - NRC)

Output Certified evaluation leading to commercialization

Work Activities:

Test various configurations

PROJECT 6 (EMR TED Wholly)

Output Improved trucking operations.

CHAPTER V

RAIL MODE

5.1 TECHNICAL SURVEYS

Rail is the Main Transcontinental Freight Mover and is in competition with the trucking mode for much of this service, particularly in intercity service. Long distance passenger service is generally not profitable.

Modernization of the Rail System focuses on optimizing use of track and rolling stock. Concentration focuses on better upkeep of fewer miles of track and improved efficiency of the traction and carriage units in their design and use.

The Majority of Tractor Units around the world are diesel or diesel/electric with the remaining steam locomotives in India and China. The more efficient electric traction has been used in the large city suburban metro systems of Europe and New York since the late 1880's. They were also used in central Europe for medium haul freight and passenger traffic until the 1950's. High voltage long distance electric traction was then developed in Scandinavia, Russia and Europe. These systems operate over several hundreds of miles provide a city to city service which are competitive with intercity air services. The most advanced rail system is that of Japan.

Long Haul Electric Traction Systems have a single overhead supply conductor which supplies power to the locomotive along the track in discrete power feeding sections. These sections may be as short as 25 km at 25 kV supply potential or 200 km at 50 kV.

In Canada Freight Train Power Demand is equivalent to that of a moderately industrialized city of 100,000 population. It is thus evident that the added power control and new locomotive requirements of electric traction would be substantial.

The Rolling Stock has become lighter for high speed passenger use with better and in some cases controllable ride features for greater comfort. Freight cars have been standardized, and standard unit container allow transfer between ships and trucks. No major advance has been made in freight carriage for several decades, although progressive freight management techniques have been introduced.

The Rail Road is essentially as it was 150 years ago and in North America is generally less well maintained over the last few decades. The use of reinforced concrete ties, automation in the rebedding operation, and welded rails are the sole advances in these years. Signalling and communication have been continuously improved, and have rendered this mode the safest form of transport.

5.2 R&D NEEDS

Rail Needs are Specific to Each Country, it is impossible to generalize on a global scale the areas which have been addressed in the following notes.

Research and Development is carried out in each industrialized country and soft operational R&D has focussed on better control of rolling stock utilization, service and remuneration, maintenance costs and fuel use.

Equipment R&D has focussed on the design of improved traction locomotives and systems for existing rail networks. Magnetic levitation and linear induction drive is a new concept for short commuter routes. Similarly, more passenger comfort has been provided by addressing carriage suspension and curve inclination compensation, and the use of new materials.

Locomotive Traction R&D has been most active in Europe and Japan and has been centered on improved high-speed electric locomotives. The diesel traction units of Europe have a higher fuel efficiency than those of North America, and remain a viable alternative to short haul air services on many routes in Europe. In Canada, Bombardier has an improved diesel traction unit which is expected to compete with units offered by General Motors.

Magnetic levitation (MAGLEV) is in operation in Europe and Japan on short routes and is being developed in Canada (UTDC) for home (EXPO '86).

5.3 R&D IN CANADA

CN and CP have Research Facilities which undertake R&D on engine and rolling stock. Canadian development experience covers the use of turbine engines, the LRC passenger train, and 50 kV overhead electric traction.

There is a Nucleus of Canadian Expertise in several areas of railway technology. The direction of near term R&D is largely controlled by CN and CP. Both rail systems operate with small financial returns and are more concerned with making present operations cost effective.

They also operate the safest mode of transport - and carry enormous financial burdens from track maintenance. R&D venture capital is therefore small and carefully controlled.

Longer Term R&D, for example high voltage electrification, is the subject of the Transport Canada Railway Advisory Board. Here key items of longer term importance are identified with joint government/industry participation and action.

Another approach would be to identify the long term functions that the rail system is to provide to the Canadian economy and to assess the alternatives by which it can meet these requirements. This approach would have the merit of basing R&D decisions on a longer time frame than at present. R&D could serve to remove uncertainties of future options and provide timely solutions. Aspects of railway electrification, or rail-truck freight movement optimization on seasonal wheat movement, could be items where future service requirements define near term R&D operations.

New Urban/Suburban Transit Rail Systems are costly and only found in cities of upwards of one million population. In Canada this applies only to Toronto, Montreal, and Vancouver. Even so, such systems can substantially reduce traffic congestion. Their export potential must also be considered.

Both Long Distance and Suburban Rail Systems should be ascribed their future roles in the Canadian economy, from which their R&D needs could be more effectively defined.

5.4 R&D AND EMR/ENERGY PANEL CONSIDERATIONS

The fuel quantity used in the rail mode is 4% of the total transport fleet, but could be the mode in which some lower cetane diesel fuels can be used.

The Fuel Quality used by CN&CP is "Off Specification" middle distillate fuel which had some attendant cold start difficulties. Engine developments to provide easier start and improved fuel efficiency (dual fuel injection prechamber design) are considered part of the fuel/engine work for EMR to follow and foster R&D solutions.

Intermodel transfer of freight service to and from trucks or the Great Lake shipping fleet is an item for study, particularly to seek aspects of fuel conservation.

5.5 EMR - TRANSPORT ENERGY DIVISION

The principal R&D areas are:

1) The evaluation of engine modifications to allow more efficient fuel use or cold start features.

2) An assessment of low cetane fuel use in the rail mode.

3) An intermodal study to ascertain fuel conservation potential from modal shift of freight.

CHAPTER VI

AIR MODE

6.1 TECHNICAL SURVEY

The fuel crisis of 1973 provoked a major change in the operational practices of airlines and set the need for more fuel efficient and higher capacity aircraft which are now gradually coming into service.

On-ground operations were changed to effect quicker loading and unloading of passengers and freight with greater computer involvement including programmed loading and balance of aircraft. Tarmac facilities were increasingly mechanized and tractor units moved aircraft to taxi stations to eliminate wasteful jet engine employment.

Air operations were streamlined to include computer optimized flight ascent, cruise and descent, often by on-board engine computer control of the engine operations. Flight course review was made to eliminate dog-legs in routing and landing procedures changed to permit more direct landing access.

Operational improvements are largely complete, some routing can be improved with additional radio beacon and radar equipment. All measures are essentially state-of-the-art development and are driven by commercial enterprise.

Aircraft changes were made to larger capacity designs taking full opportunity of computer aided design in the geometry of structure and material utilization. New lightweight composite materials were developed for control surfaces and are now being developed for load bearing functions. Work in this field continues with the addition of shaped elements of greater strength, durability and less weight, together with new concepts of control signalling to eliminate cabling weight and materials.

Advances in computer analysis and modelling have provided major breakthroughs in aerodynamics. Advances in these studies are already providing new wing concepts and future advances in body shape integration will present new body/wing forms.

Drag reduction provides the greatest potential for increased flight efficiency by reducing skin friction drag.

Propulsive lift by directing forced air flow across surfaces has lead to concepts of spanwise or chordwise wing blowing which will improve take-off and landing characteristics. Techniques employing wing power profiles to generate propulsive lift have the potential to increase the lift-to-drag ratio by 25% thereby providing range increase.

Propeller aerodynamic technology, dormant since 1955, has been in active development over the last ten years for March 0.7-0.8 cruise application.

Projected improvements for high speed turboprops show a 15 to 30% fuel saving over a conventional turbo propeller jet engine, using a scimitar blade shape. An additional 8-10% appears possible by partially recovering swirl losses by using a counter rotational second propeller system. These developments are scheduled for extensive flight trials in 1987 and 1990 respectively. Noise problems are largely solved.

6.2 R&D NEEDS - GENERAL

The above areas of research and development are taking place in the USA, Europe and Russia.

The R&D needs are self-generated in each of the above areas and are supported by strong military interests.

6.3 R&D ROLE - CANADA

Canada's aerospace industry is very small and specialized. Apart from specific design commissions such as the space-arm, it is an industry largely using the results of R&D advances made in the USA and Europe. It has good design capability, but limited in size to its commercial activity. It has a need to keep abreast with developing technologies, particularly manufacturing techniques.

6.4 R&D ROLE - FEDERAL GOVERNMENT/PANEL ON ENERGY R&D

Canada's strength in this field is in small passenger and commuter type aircraft of limited range. The industry operates in a highly competitive area of intense technical development. It serves the need for specialized small aircraft to link the more remote communities of Canada. As such, the industry is a national asset that should be supported. The critical mass of expertise necessary to sustain the application of these next technologies is unlikely to be found from the profitability of current company operations. It is therefore necessary for government to support an "applications" role for this industry in future years. It is unrealistic to expect this industry to survive on the present cadre of engineers.

The energy R&D panel generally funds projects having an effective energy saving within a time period of up to ten years. The Canadian aircraft industry R&D requirements are of a different nature to those generally reviewed by the panel and are in a much longer time frame.

Specific endeavours of engine and airframe development should continue to be addressed in the absence of a more appropriate industry focussed government support program. In particular, the work with Pratt & Whitney, De Havilland & Canadair administered by T.C. should be continued on this basis.

6.5 R&D ROLE - EMR - TRANSPORT ENERGY DIVISION

There is no R&D project activity affecting fuel quality or conservation identified for EMR support at this time. There is likely to be a modal use study made during the next year, but no specific fuel quality/conservation projects are foreseen.

CHAPTER VII

MARINE MODE

7.1 TECHNICAL SURVEY

Vessels in the marine mode vary from ocean going ships powered by low speed diesel engines or steam turbines, through to the fleets of coastal freight, passenger craft, fishing fleets, tugs, and barges. The latter fleets are largely powered by medium or high speed diesel engines, but some of the lake fleet is turbine powered.

The propulsion system is by propellers - only a few specialized ferry craft use air cushion (UK) or hydrofoil (Russia) buoyancy systems with air propellers for their propulsion.

Hull Design is special to the type of weather condition and cargo, the most significant changes in hull design occurred about 30 years ago in the then new era of 100,000 ton supertankers.

The increased cost of fuel now places the fuel at about 40-55% of operating costs in this mode. R&D has therefore turned to improved engine efficiency, reduced hull drag, and improved propeller design. However, this mode is ultra conservative and the longevity (greater than 30 years) of ships coupled with the economic recession of the last decade has pervented new design trends.

The fuel quality available for oceangoing vessels has degraded enormously. The composition of these fuels is much more aromatic and difficult to burn in diesel engines. The refinery "cut" is in the heavy fuel end which is often richer in refinery catalyst fines which have deleterious to the diesel engines. Ocean going vessels have on board fuel treatment equipment to remove water and lower viscosity by heating and recently, by additives. Some ships now perform a limited fuel test on bunker-fuel samples before acceptance.

7.2 R&D NEEDS - GENERAL

R&D has been done on more fuel tolerant engines but these are largely of Scandinavian, European and Japanese origin. Due to the 30 year life cycle of a heavy marine engine, few have been commissioned in the last decade.

Hull Drag Reduction Practices of "slow steaming" have been in operation for some 10 years to reduce fuel consumption. Low friction coatings have been developed to reduce hull drag.

Hull form has not significantly changed, but stern turbulence reduction has received study in Europe and Japan with considerable R&D being done on propeller design.

The traditional stern propeller system requires attention. It operates in the returning flow of displaced hull water around the stern of the ship. The propeller therefore operates in a stream which can be turbulent and in any case has only a limited effective speed range.

The propeller efficiency may perhaps be extended by reducing turbulence eddies associated with hull/propeller interaction.

Fuel management in shipping has been studied to some extent and perhaps is the most rewarding and immediate approach. In coastal operations between 10 and 30% fuel economy has been achieved by limited application of control systems.

7.3 R&D NEEDS IN CANADA

The Atlantic and Pacific ship building industry of Canada is in the doldrums. Although there is little or no shipbuilding, the industry must be aware of and ready to embody the progress of others. One need may very well be to seek and record the progress has been made in marine design. Canadian resources to apply R&D are limited, but exist in Vancouver, Halifax and St Johns Newfoundland.

Hull Form and Propulsor Systems R&D confirming new design approaches is done at the marine laboratories at Halifax, St. John, and Ottawa. They respond to the needs of ship designers and builders. Design is largely undertaken by commissioned naval architects.

Energy Monitoring of Design Change R&D could be achieved using recently developed fuel management systems to provide in service data.

7.4 R&D ROLE - FEDERAL GOVERNMENT/PANEL ON ENERGY R&D

Lake fleet, ferry and tug operations have been visited, it has not been possible to obtain input regarding the ocean and fishing fleets. How R&D from government operations interacts with these industries is not fully known. Informative telephone contacts were made to the Institute of Marine Dynamics (St Johns) and the Defence Research Establishment (Halifax).

Fuel management systems is a promising Canadian initiative being developed from an early fuel recording system employed in the BC ferry services. This is currently being supported by EMR in a demonstration phase. It is hoped that the operating procedures resulting from this work can be applied to the lake fleet and coastguard.

R&D associated with fuel management should be supported. Areas affecting fuel consumption are :

- R&D on fuel management system sensors and computing systems
- R&D an improved propulsion efficiency
- Interactive stern hull flow
- Improving fuel management by developing operational methodology for particular marine modes (eg. ferries, tug operations, coastal/lake freight)
- Reduced tow energy from improved position control of barges
- R&D in on-board handling of degraded diesel fuels.

A preliminary search into the areas and results of R&D being undertaken in Scandinavia, Europe and Japan is recommended. This would avoid duplication.

The Energy Panel should fund the summary report and any ensuing R&D.

7.5 ROLES AND ACTIVITIES - EMR - TRANSPORT ENERGY DIVISION (TED)

Fuel quality concerns of the ocean fleet have yet to be sought. Although they are known to be severe, the fleet is small and the concern is largely when refuelling in non Canadian ports. These concerns should be addressed by TED.

Fuel management techniques have an enormous contribution to make which is enhanced by the ability to give "managerial information" rather than a speed or flow measurement. This R&D should be fostered by TED and the ENERDEMO program.

Improved propulsion from turbulence reduction based on hydrodynamic research is appropriate support for Canadian ship builders. The R&D would be centred and coordinated by the Institute of Marine Dynamics at St. Johns Newfoundland, using facilities of Universities, provincial research centres, and federal government facilities at Halifax (DREA) and Ottawa (NRC). Bow and hull tunnel propulsion systems should be explored in addition to stern propulsion.

MODAL TECHNOLOGY REVIEW

ROAD MODE

Light Duty Cars & Trucks (48% Transport Fuel Consumption)

		1985	1990	1995	2000
1985	Av. Pas. Car Fleet Fuel Consumption	12.4 ℓ/100km	10.2 ℓ/100km 7.9 ℓ/100km	9.2 ℓ/100km 7.4 ℓ/100km	9.0 ℓ/100km 6.9 ℓ/100km
	New Car Consumption	8.6 ℓ/100km	7.9 ℓ/100km	7.4 ℓ/100km	6.9 ℓ/100km
	Av. Light Truck Fleet F.C.	17.0 ℓ/100km	13.0 ℓ/100km	12.1 ℓ/100km	10.0 ℓ/100km
	New Light Truck Consumption	10.5 ℓ/100km	9.6 ℓ/100km	8.8 ℓ/100km	6.0 ℓ/100km

1990 Projected Fuel Consumption

Developing Fuel Efficient Technologies
(Near Term - To 1990)

- Turbo/4 Valve Engines, & 60HP/ℓ small engines
- Increased Fuel Injection
- Increased electronic Control of Engine & emission Systems
- Lighter weight; Early CVT & Fast Burn/Lean Combustion

1995 Projected Fuel Consumption

Advanced Fuel Efficient Technologies
(Intermediate Term - To 1995)

- Compact - 4 Valve Small engines; 80% FI; 50% STD Transmission
- Intermediate - 4 Valve 2ℓ + Fast & Lean burn + CVT; FI
- Full Size - 4 Valve 2.6 ; 2 Tier Power Boost + CVT; FI

Longer Term Fuel Efficient Technologies
(Application 1995 - 2000)

Benefits Over 1995

Micro (car) - 4 Valve Small engine; Carb	0.75ℓ/100km
Compact - 4 -Valve CVT, FI	1.0ℓ/100km
Intermediate - 4 Valve, Power Boost, CVT; FI	2.0 ℓ/100km
Full Size - Ditto, Some	2.6 ℓ/100km

EMR ACTIVITY - GIMVEC

Interacitive Government & Industry Liason — On-going
In Areas of Fuel Quality, Fuel Economy

R & D

Only Policy Related Specific Fuel Concerns
eg - Fuel Quality - Emission Concerns
Canadian Specific Advanced Fuel Economy Developments
- Improved Cold Fuel Economy

ROAD MODE

TEB ACTIVITIES

Automobiles, Light Duty Trucks, Intermediate & Heavy Duty Trucks

Fuel Economy Monitoring & Review

Surveys

(Type & Use) Journey to Work (Stats Can)

Fuel Use - 12000 Cars (Stats Can)

Studies

AUTOMOBILES

1) Update LDV Fuel Consumption Data Base — (1)

2) Commence Technology Development Data Base — (2)

3) Establish Model For Cost Effective Technology Assessment — (3)

4) Reiterative Coalescence of 1, 2 & 3 To Ascertain Potential Fuel Consumption Benefits Against Actual Use of New Technologies — (4)

LIGHT DUTY TRUCKS

5) REPEAT 1-4 ABOVE BUT FOR LIGHT DUTY TRUCKS — (5)

6) — (6)

7) — (7)

8) — (8)

POLICY PAPER

9) Prepare Policy Support Paper Reviewing LDV CAFC Annual Achievements & Levels — (9)

10) Establish A Fuel Specification Data Base - Gasoline With Octane Boosting Components; Diesel & Cetane Enhancers — (10)

FUEL QUALITY CONCERNS

11) Examine MMT Concerns Regarding New LDV Emission Standards (DOE - Lead Agent - Via CGSB) — (11) MMT Deposition in O_2 Sensor & Catalyst

12) Examine Alcohol Oxygenates/Octane Boost & Additives

13) Monitor Diesel Quality and its Interaction With Emissions

14) Monitor Refinery Structure & Guidance to Lower Cetane/Higher Aromatic Qualities — (12) Field Fuel Use/Quality-Quality Performance

(13)

(14)

INTERMEDIATE & HD TRUCKS

15) Establish An Intermediate & Heavy Truck Data Base - Types Of Truck — (15)

16) Establish Emission Technology Data Base For H.D. Trucks — (16)

17) Establish A truck Technology Data Base — (17)

18) Reiterative Examination Of 13, 14 & 15 To Examine Fuel Saving Potential — (18)

ROAD MODE CONT'D.

TEB ACTIVITIES

R & D	Cost Effectiveness Study	Demonstration
Identify New Technologies Contract Any Advanced High Risk Canadian R&D For Proof Of Principle eg Side Cooling (NRC)	To Assess	To Demonstrate
As Above	To Assess	To Demonstrate
Evaluation & Support Sort R&D	Periodic Review	
Low Cetane (37-35) Fuel In Trucks (TED)	To Assess	To Demonstrate
Evaluate Canadian Fuel Emission Impact Impact & Pursue Trap or fuel Quality Solution	To Assess	To Demonstrate
Development Of Rear Drag Pressure Compensator	To Assess	To Demonstrate

URBAN TRANSPORT SYSTEM

ENGINEERING R & D TOWARD MORE ENERGY EFFICIENT VEHICLES

URBAN VEHICLES

Bus - Straight Power Units

Diesel Move From 2 Stroke To 4 Stroke

Matched Engine/Road Load Transmission System
(Intelligent Gear/CVT Control)

Electric Trolley - Chopper & High Efficiency Motor

Hybrid Power Units Based on Internal Combustion Engine (ICE)

Diese /Hydraulic — Development Of Power Charge/Discharge Systems & Power Source Control Systems

Diese /Flywheel

Electric Trolley - Battery
Extended Range Vehicle

NOTE: ICE/Electric is Considered Not Cost Effective

Body Systems

Single Decker

Articulated

Double Decker

(Involvement of CVT)

Train - Urban

Train - Bus

"Go-Train"

People Movers

Unit Train (MAGLEV and Induction Motor)

Moving Belt Travelators

Intermediate Capacity Transit System

1) MUNICIPAL MANAGEMENT	Survey	Study	R & D	Cost Benefit	Demonstration
Demand Management Measures					
Staggered Working Hours Ridesharing Parking Control Transit Service & Pricing Shared Ride (Jitney) Operations Bicycle Pathway Incentives Travel Substitution - Teleconferencing & Data Exchange Pedestrian Access Ways	List & Examine All Available	List & Examine All Available & Their Social & Economic Effectiveness &	Identify R&D Required	Study On Any Item Regarding Social & Economic & Energy Benefits	Operate With A Pilot MU NI CI PA LI TY
Supply Management - Road Systems					
Parking Limitations (Downtown) Park & Ride (Fringe Park & Transit Use) Traffic Engineering Computer Traffic Light Control I) Optimised Route Flow II) Improved Junction Coordination Replace 4 Way Stops To "Caution" Introduce Transit & Taxi Express Routes	Identify Missing Areas For Study	Identify Missing Areas For Study	Probably Only In Traffic Engineering		
Supply Management - Transit System					
No. & Design Of Routes Frequency of Busses & Headways Public Information Update Priorities - Exclusive Bus Lanes - Transit Signalling - Transitways					

Urban Form - Energy Optimised Siting & Design Of Dwelling & Work Units. - Not An EMR Activity But An Important Long Term One

TRUCKS ENERGY EFFICIENCY - Operating	Surveys (Or Preliminary Studies)	Studies	R & D	Cost Effective Study	Demonstration & Transfer
AREAS OF IMPROVED FUEL EFFICIENCY					
LOCAL DELIVERY CLASS 1-2-3					
Choice of Vehicle & Fuel Route Optimization	Vehicle Fuel Saving Devices Route Features Of Commonality	Define For Each Area	Develop & Test Devices Develop Route Aids	Check	Demonstrate With Truck Associations
INTERCITY CLASS 4-5-6-7					
Choice of Fuel & Vehicle Optimized Vehicle Use	Find Deisel-Gasoline Use & Fuel Preference Ascertain Vehicle Types Ascertain Use Patterns	To Switch To 100% Diesel Use Categorize for Use Inventroy & Define Any Improved Use From Operations Optimization	Apply in Defined Efficiency Goal	Check	Demonstrate With truck Associations
LONG-HAUL Class 8					
Choice of Vehicle & Fuel	Ascertain Use Patterns				
Inter-Modal & Operating Practices	Ditto				
Cold Start Practices	Ascertain Various Cold Start Pracices & OEM Options	Identify R&D & Demonstration Areas	Mount R&D	Check	Demonstrate & Hold Workshop On RTAC/Truck Meeting
Alternative Fuel					

TEB ACTIVITIES

TRUCKS ENERGY EFFICIENCY - **Vehicle**

AREAS OF IMPROVED FUEL EFFICIENCY	Survey	Study	R & D	Cost Effectiveness	Demonstration
ENGINES - High Torque Rise	? All Makes	-			
Cooling - Accessories	-	-	Possible	Check	Make
Fundamental Design			Initiation		
Accessory Drives	-	-		Check	Make
Fuel (Cetane) Tolerant	Work in Progress	-	Check Out With Advanced Engine Manufacturer & Compact		
Computer Optimization (Emission Control)					
TRANSMISSIONS			Tests On 5 Diesel Fuels Of Various Levels - See Last Item		
- Automatic	-				
CVT	-				
AERO DRAG					
- Farings		List			
Seals	Available	&			
Compensators	Retrofits	Examine	Possible Initiation	Check	Make
WHEEL		All Available			
Bearings	-	Studies	Possible	Check	Make
Tires	% Radial	&	Initiation		
Unit tire	-	Technical Papers & NRC			
BRAKES - Inertial Recovery Of Energy - Refer To Bus Technologies	Application In Local Delivery (Not Until 1990)	On bus	Hybrid Drive	Check	
FUEL QUALITY - Low Cetane Impact	-	Completed	In Hand On Current Engines	To Be Made	To Be Made
Low Cetane - On Advanced 7 & 8 Class Truck Engines			Initiate R & D	Check	Make

RAIL MODE

	Study	R & D
OPERATIONS		
Computer Assisted Train Despatching		
- Load & Power Matching - short (50 Unit) Freight Trains	Identify Areas & Methodology	
- Reduce Return Empties	Assess Operational Parameters	
Improved Track Occupancy	Identify Areas & Methodology	
- Signalling Improvements To Reduce Heading Times	Identify Existing & New Options	
- Local Double Tracking	Cost effectiveness For New Operational Facility	
ROLLING STOCK		
Traction Stock		
- Train Traction Management	Define Short (50 Unit) Train Power Management	
- Slow Idle Running	& Optimize Slower Winter Idling/On-Off Idling	
- Wheel Slip Control - Speed/Sanding	Commessurate Wheel Speed & Traction Control	
- Reduce Auxiliary Power Demands	Identify Solid State Power Management	
- Advanced Diesel Design - Insulated Combustion System	Both Long & Major Items	
- Main Line Electric Traction	Term	
Freight/Passenger Stock		
- Reduced Weight	Material & Construction Review - CAD	
- Self Steering Trucks	Review Position For Introduction	
- Reduced Aero Drag	Identify Inter Carriage/Wagon Gap Seals & Efficiency	
- Low Maintenance Concepts	Detailed & Unconstrained	
On I) Hotel Services	Study INCLUDING	
II) Rolling & Brake System	Repair Shop Methodology	
III) On Board systems Monitoring - eg. Solid State Hot Box Detectores	& Mechanization Aspects	

MARINE I

1) LAKERS	OPERATION SUMMARY	IDENTIFY CONCERNS	R&D AREAS	R&D PROJECTS
Propulsion				
Composition Of Propulsion Systems			Fuel Management Systems	
Diesel				
Steam Turbine				
Other				
Fuel				
Fuel Treatment Systems On Board				
Fuel Concerns & Actions				
Fuel Use Monitoring	Not Monitored Systematically	Try to Form a Universally Applied Method of Fuel Use Measured to Monitor Technology	Try Out A Fuel Use Monitoring System	Demonstration Of A Fuel Use Monitoring System
Engine Concerns & Actions				
Engine Preferences				
Engine/Vessel Renewal				
Advanced Systems				
New Engine Fuel Quality Accommodation				
Navigations /Communication Matters				
Assisted Wind Propulsion				

MARINE I (continued)

Advanced Systems

Propellor Improvement

Reduced Hull Drag

Operations Extension From Ice Breaking

Modal Freight Shift

MARINE II

2) COASTAL FREIGHT	OPERATION SUMMARY	IDENTIFY CONCERNS	R&D AREAS	R&D PROJECTS
Propulsion				
Diesel				
Steam Turbine				
Fuel				
Treatment Systems On Board				
Fuel Concerns & Actions				
Engine Concerns - Actions Preferences				
Engine/Vessel Renewal				
Towing Types of Vessels Towed				
Barges, Types - Steerage & Drag	OFF - "Line Astern" (Causing Energy Losses)	Servo Control On Barge Missing	Servo Rudder Control From Tow Line	Tow Trials in BC
Operational Studies/R&D				
3) FISHING INDUSTRY				
Propulsion - Diesel Engines & Wind				
-Propeller Improvements		Various Hull Shape	Guidance In Choice	DFO Short List of Hull & Trials of
-Hull Improvements	Categories	of Hull of Propellor	Stern Shapes Retrofit Areas	Hull & Stern Retrofits

MARINE II (continued)	OPERATION SUMMARY	IDENTIFY CONCERNS	R&D AREAS	R&D PROJECTS
3) FISHING INDUSTRY				
Fuel Concerns				
-Fuel Use				
-Switch to Diesel				
Operational Improvements				
-Fleet Monitoring From Shore	Radio Link to Shore of Fuel Use & Position		Radio Telemetering of On-Board Fuel Management System	Trial of Prototype

MARINE III

4) OCEANIC - FREIGHTERS & TANKERS	PROBLEMS		THOUGHTS
Propulsion Diesel			
Steam Turbine			
Oil Fired			
Coal Fired			
Fuel			
On Board Equipment Centrifuges	- Distillates - and -	Residuals	(Spec. Problems - ISO WG 6 18/5/85)
Heaters			Europeans Pushing
Other	Have Ignition	Do not have	Even Tho. Cat Fines & Sediments
Engine Concerns & Actions	Criteria-both No(Engine) & Indices- $\frac{APx\emptyset}{100}$ (I)	Ignition Criteria	Not Considered
Engine Changes/New Designs	& New MNR (II)	Possibly	
Engine Renewal Cycles	Proton	NRC MNR	
	Mixes Can Cause "Sludgeability" At Low Temperature Paraffinics Form Waxes Mix of Both Can Cause Asphaltenes & Can Get Fe_3O_4 In H_2O - Solvent Approaches		
Hull Design Changes			
4) OCEANIC - FREIGHTERS & TANKERS			
Low Friction Coatings			
Laminar Liquid Friction Control			
Operational Improvements			

AIR MODE 1

OPERATIONS

1) Passenger

Computer Assisted Loading & Balance
Flight Scheduling (Altitude & Directions)
Flight Control (In Flight Routing)
Engine/Routing Control

Flight Course Optimization (Dog-Leg Course Elimination)
Radar & Radio Beacon

Air Traffic Control
New Generation Radar Control System
I) Local
II) Approach
III) Distant

Re-Equipment
New Aircraft Size/Capacity Planning & Route Allocation

Passenger Handling Systems

2) Freight

Above

Plus Freight Scheduling - Computer Assistance

3) Fuel Jet A - Some Jet B?

Alternative Fuels - 2,020AD
H_2 & MeOH?

AIR MODE II

AIRCRAFT

Long Haul

New High Capacity Higher Efficiency Aircraft
eg Boeing 767 757 - A310-320

Intermediate Range

Short Haul

STOLS

ENGINES

SubSonic & Ultrasonic
Turbofans - Increased Bypass Ratio
More Energy Efficient

SubSonic
Turboprops - Single & Double Unducted Fan Jets
Fuel/Speed Computer Control Systems

LIFT & CONTROL SURFACES

Laminar Flow Control
Innovative Plan Form & Controls
High Strength Composite Light Weight Controls - SOME CANADAIR WORK

BODY CONSTRUCTION

Optimised Structural Designs Employing
New Metal Forming Techniques & Composite Filament & Laminate Structures